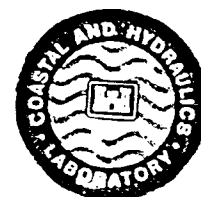




Coastal Engineering Technical Note



The Harvest Experiment

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PURPOSE

The purpose of this technical note is to describe the approach and results of the Harvest Experiment, a 4-month, co-located deployment of four different types of directional wave gauges in a high-energy environment, and direct interested users to the on-line version of this report. Using the Internet and any commercial browser, a detailed description of the study, as well as measured time series, analyzed spectra, and reduced parameters can be viewed in tabular or graphical form, or downloaded for use by the engineering and research community. The next phase of the Harvest Project will utilize these data in an in-depth intercomparison to better quantify uncertainty in measured wave data products.

BACKGROUND

The Harvest Project is occurring in two phases, the Harvest Experiment (HarvEx) and the Harvest Intercomparison (HarvIn). HarvEx consists of a long-term, co-located deployment of four different types of wave gauges in a high-energy environment; analysis and reduction of the data to a common standard; and dissemination of all of the measured and analyzed data to the engineering and research communities. HarvIn consists of detailed statistical analysis of subsets of the HarvEx data set to better quantify the effects of gauge design on the uncertainty in analyzed products. The Harvest Project is a product of the U.S. Army Corps of Engineers Field Wave Gauging Program (FWGP).

The FWGP collects and disseminates wave data from gauges located around the U.S. coastline for use in planning, designing, and managing Corps coastal projects (U.S. Army Engineer Waterways Experiment Station, monthly publication). In addition, the Program supports improvements in wave measurement technology and enhancement of wave data quality and utility. For example, the FWGP Wave Data Analysis Standard (WDAS) (Earle, McGehee, and Tubman 1995) documents the analysis procedures used by participants in the FWGP, and specifies the standard spectral and parameterized wave products provided to users. Currently, these products can be accessed via the Internet from the "Big Wave" data access and viewing engine. The FWGP Wave Climate Standard (in preparation) will provide similar documentation and specification for climatic statistics produced by the program.

FWGP data are obtained from three sub-networks using a variety of state-of-the-art wave measurement systems, each with different attributes. Pressure arrays have been used in coastal

research for decades because they function in the high-energy surf zone. They do not require data corrections for buoy/mooring response, and potentially provide greater directional resolution. However, pressure arrays are usually deployed in shallow water (5 - 15 m) because of limitations in detecting high frequency wave pressures that are attenuated in deeper water. The Datawell Waverider™ buoy is a widely used commercially available buoy suitable for short to reasonably long deployments from relatively small vessels. Discus buoys are relatively large buoys that also provide meteorological and other oceanographic data, are designed for long-term deployments on the order of years, and require substantial vessels for deployments. Buoys are not usually deployed in shallow water where they will be exposed to breaking waves.

Each of the Harvest Experiment gauges is known from experience to provide high-quality data, but the limitations of the sensors, the signal processing, and the theories and assumptions used in the analyses have never been integrated with standard sampling theory into a comprehensive uncertainty analysis. The existence of a pressure array on the legs of the deep-water Harvest platform allowed operation of these gauges in a high-energy, mutually comparable environment.

EXPERIMENT DESIGN

HarvEx was conducted from October 1995 through January 1996 using four different types of wave gauges sited on, or in the vicinity of, the Harvest oil production platform. The platform is located approximately 20 km (10.8 n.m.) west of Point Conception, California, in water with a mean depth of 202 m (663 ft). Wave conditions are representative of those beyond the islands off Southern California. The location is routinely exposed to large waves generated by winter extratropical storms moving across the Pacific Ocean further to the north. Local bathymetry and gauge locations are shown in Figure 1. The average distance between the gauges is approximately 1 km (~3300 ft). Although all of the gauges measure waves representative of the location and with similar wave statistical properties, the gauges do not measure the same individual waves.

The gauges are described below:

- Station 06301 - A multi-element array of subsurface pressure sensors mounted on the platform, operated by Coastal Data Information Program (CDIP). It is located at (34.4726° N), (120.6794° W), and has horizontal dimensions of approximately 23 m (75 ft) by 65 m (213 ft).
- Station 07101 - A Datawell Waverider directional wave buoy operated by CDIP, located at (34.4750° N), (120.6900° W). It is a widely used, commercially available directional wave measurement system manufactured by Datawell (Holland). It is a 0.9-m-diam spherical buoy that weighs 212 kg. The Waverider mooring contains sections of rubber cord to partially isolate mooring loads from the buoy.

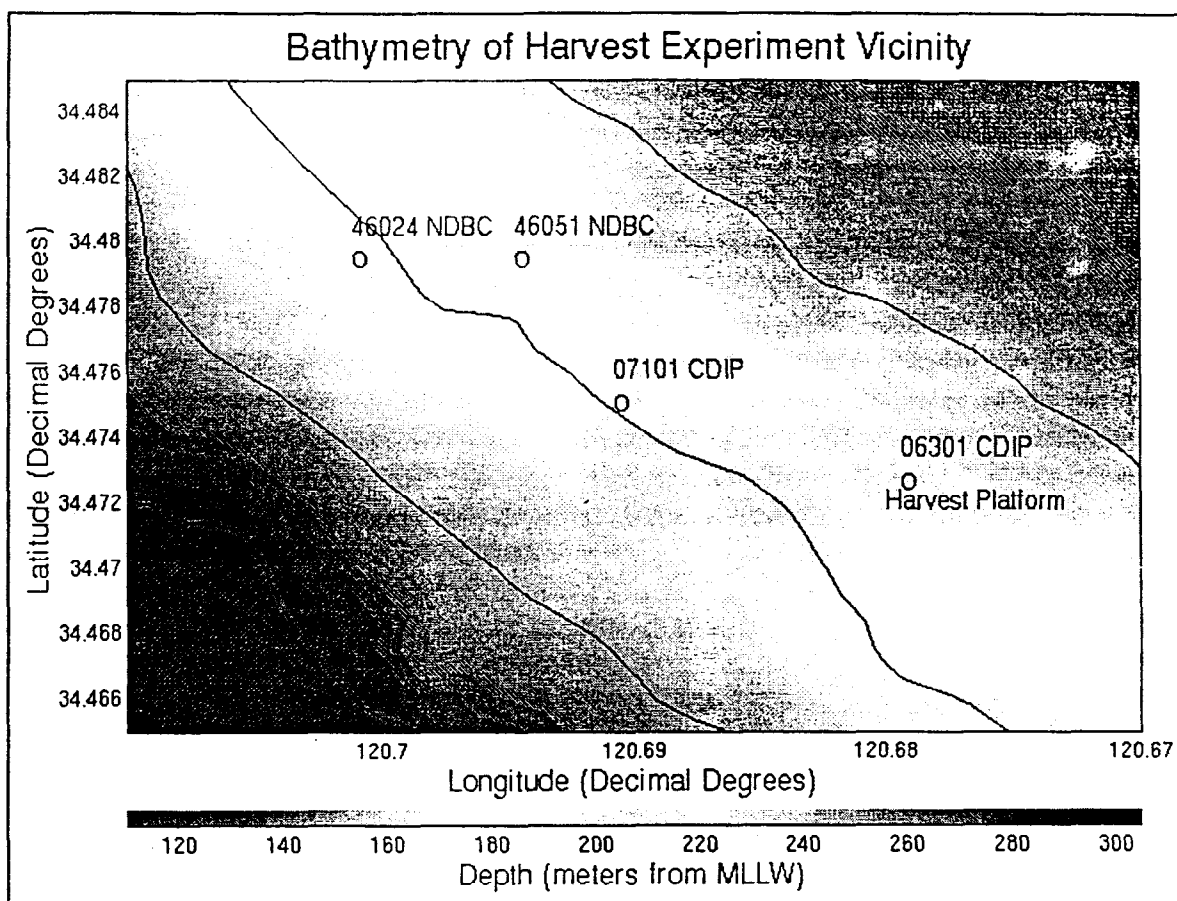


Figure 1. Harvest Experiment gauges and local bathymetry

- Station 46024 - A standard National Data Buoy Center (NDBC) directional 3-m discus buoy deployed at (34.4794° N), (120.7011° W).
- Station 46051 - An experimental NDBC directional 3-m discus buoy deployed at (34.4794° N), (120.6947° W). It is very similar to 46024, but it does not have the "bell clapper" subsurface mooring structure used on the standard buoy; rather, the mooring attaches directly to the bottom of the discus buoy.

DATA

While the Harvest pressure array has been operational since 1989, HarvEx covers the period of deployment of the four gauges from October 1995 through January 1996. The two NDBC buoys were operational for nearly all of the 4-month experiment. The pressure array began intermittent operation in early December, and was only providing nondirectional data from mid-December through January. The Waverider was deployed in early December, and operated through the end of the experiment. Altogether, there are two adjacent 2-month periods when

three systems were operational; but the period of simultaneous operation of all four gauges is only about a week.

Data products include: measured time series for each sensor; 2-D energy density spectra; and reduced wave and meteorological parameters. The reduced parameters include significant wave height (H_s), peak period (T_p), dominant direction (D_p), wind speed (W_s), wind direction (W_d) and atmospheric pressure (P_a). The spectral products contain, for each frequency band, the energy density, the mean direction *from which* the energy is coming, relative to true north, and the first five Fourier coefficients of the directional spectrum (a_0 , a_1 , b_1 , a_2 , and b_2) in an earth-fixed coordinate system. The WDAS spectrum results from Fourier analysis of a 2,048-sec time series of 1-Hz samples. Because the sampling frequencies for the NDBC buoys and the Datawell Waverider are not exactly 1 Hz, the analyzed frequency bands produced from these systems did not match the WDAS frequency bands. In order to permit display and comparison of the various systems using a common spectrum, their nondirectional wave spectra and directional spectra Fourier coefficients were interpolated linearly to WDAS frequency bands. This procedure is analogous to performing interpolations as a function of frequency for standard Longuet-Higgins, Cartwright, and Smith (1963) directional spectra.

Each data product can be selected, viewed as either an ASCII text file or a plot, and downloaded via the Internet through a modified version of the FWGP "Big Wave" data access and viewing engine. The address is:

http://cdip.ucsd.edu/harvest_experiment/homepage.shtml. Figure 2 is an example of a comparison of height, period, and direction for stations 06301(Harvest Platform) and 46051(Harvest Experimental) for the month of November 1995.

SUMMARY

The Harvest Experiment (HarvEx) was a 4-month, co-located deployment of four different types of directional wave gauges in 200 m of water near Point Conception, CA. The experimental design, the gauges, the sampling and analysis plan, and the data products were presented. This paper is a complement to a World Wide Web (WWW) site that allows access to all of the data collected in the experiment. Using current web browsing software, anyone in the engineering and research community can view and/or download measured time series, analyzed spectra, and reduced wave and meteorological parameters. In spite of the different gauges, sampling schemes, and analysis used, all data products are presented in the common FWGP WDAS format. The data will be used in the next phase of the Harvest Project to better quantify the actual uncertainty in measured wave data products.

For Additional Information - contact Dr. Andrew W. Garcia, (601) 634-3555, or via E-mail at a.garcia@cerc.wes.army.mil or visit the Field Wave Gauging Program home page at <http://cdip.ucsd.edu/fwgp.html>

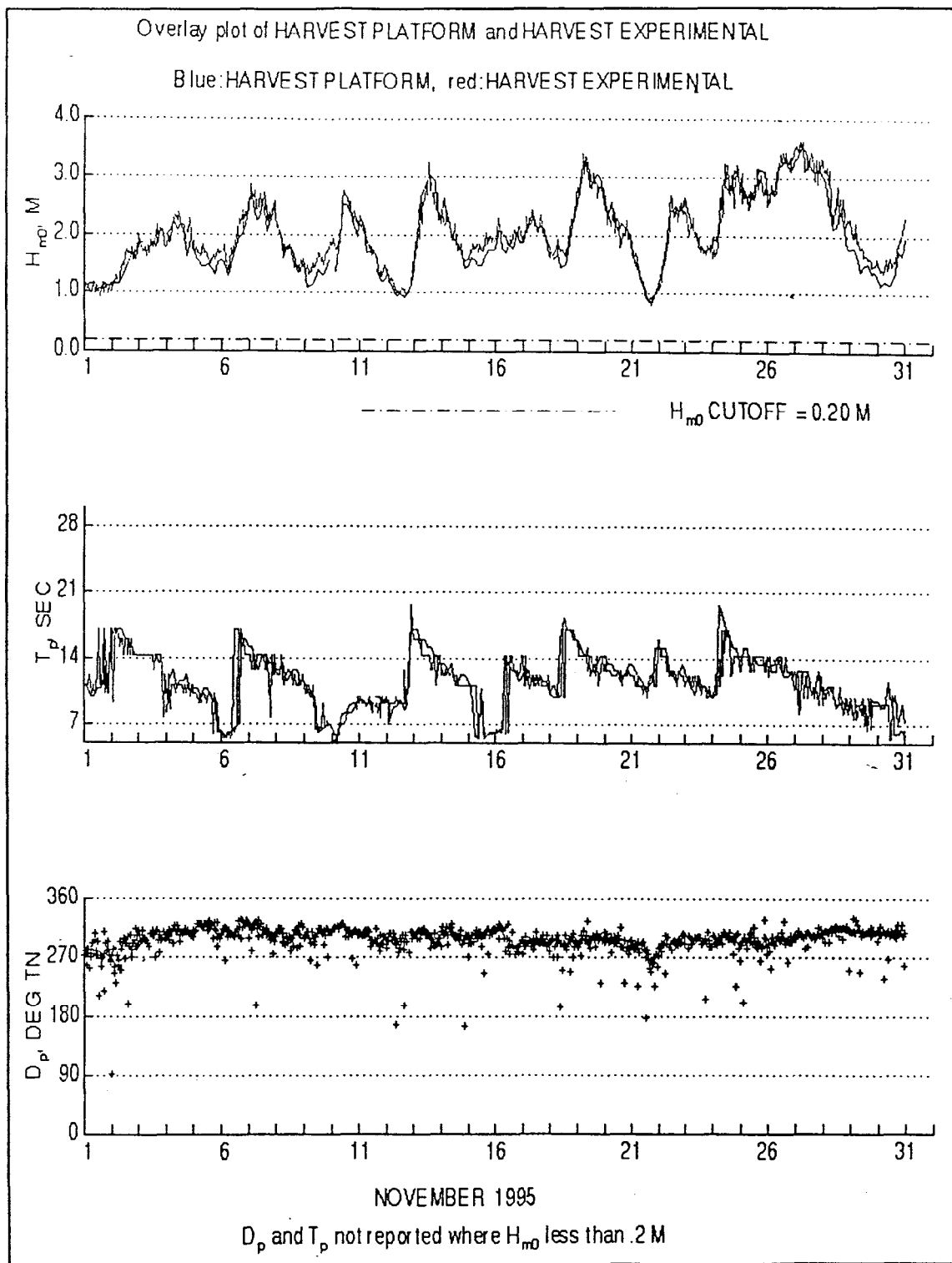


Figure 2. Example of intercomparison of results (from WWW site)

ACKNOWLEDGMENTS

The Harvest Project is a product of the Field Wave Gauging Program (FWGP), a research program of the U.S. Army Corps of Engineers. The FWGP is managed by the U.S. Army Engineer Waterways Experiment Station (WES) Coastal and Hydraulics Laboratory (CHL). The Program primarily acquires data from three gauge networks: the moored buoy program operated by the National Data Buoy Center (NDBC), a component of the National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA); the Coastal Data Information Program (CDIP), operated by Scripps Institution of Oceanography (SIO) under joint sponsorship of the Corps and the California Department of Boating and Waterways; and the Network for Engineering Monitoring of the Oceans (NEMO), operated by the Prototype Measurement and Analysis Branch (PMAB) of CHL.

The FWGP Principal Investigator, Mr. David McGehee, conceived and planned the Harvest Project. This paper was prepared by Mr. McGehee and Dr. Marshal D. Earle, Neptune Sciences Inc. The WWW version of the report was developed by Ms. Julie Thomas and Messrs. Grant Cameron and Michael Nichols of SIO, under the supervision of Mr. David Castel. The intercomparison was performed by Drs. Earle; Leon Borgman, University of Wyoming; and Robert Hudspeth, Oregon State University. This experiment would not have been possible without the cooperation of Chevron, Inc., the owners of the Harvest Platform.

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